1 IMPORTANCE OF CLEANING SYSTEM

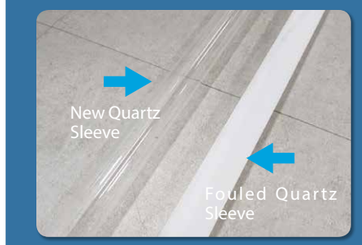
UV system should provide the design UV dose even when the quartz sleeve fouling accumulates and lamp approaches the end of life. The UV dose should include the Combined Aging and Fouling (CAF), which is equal to end-of-lamp-life (EOLL) multiplied by fouling factor (FF). EOLL is a ratio of the new lamp output to that of the lamp at the end of life and FF is the estimated fraction of UV light passing through a fouled sleeve as compared to a new sleeve.

Absorbing UV light, fouling decreases the UV transmittance of the sleeve and the intensity of UV light penetrating into the water to be treated. Thus fouling significantly impacts the efficiency of the UV reactor and results in higher power consumption to compensate the loss of the UV intensity.

Quartz Sleeve Fouling

Various compounds in water can contaminate the surface of quartz sleeve of the UV reactor due to the following reasons :

- Compounds for which the solubility decreases as temperature increases may precipitate [e.g., $CaCO_3$, $CaSO_4$, $MgCO_3$, $MgSO_4$, $FePO_4$, $FeCO_3$, $Al_2(SO_4)_3$]. These compounds will foul MP lamps faster than LP or LPHO lamps because MP lamps operate at higher temperatures (EPA 2003).
- Photochemical reactions that are independent of sleeve temperature may cause sleeve fouling (Derrick 2005).
- Compounds with low solubility will precipitate (e.g., $Fe(OH)_3$, $Al(OH)_3$). (EPA 2003)
- Particles in water can deposit on the lamp sleeve surface due to gravity settling or turbulence-induced collisions. (Lin et al., 1999a).
- Organic fouling can occur when a reactor is left off and full of water for an extended period of time (Toivanen 2000).
- Inorganic constituents can oxidize and precipitate (Wait et al. 2005).



Bubble Clean System

2 TYPES OF CLEANING SYSTEM

There are three types of the UV reactor quartz tube cleaning systems: Off-line Chemical Cleaning (OCC), On-line Mechanical Cleaning (OMC), and On-line Mechanical-Chemical Cleaning (OMCC).

OCC System

OCC system flushes out the UV reactor with a chemical cleaning solution while the reactor is taken off-line and water is drained from the reactor. To dissolve the foulants on sleeve surface, the cleaning solution fills up the reactor (or sprays into the reactor through a service port) and rinses for a period of time before the reactor returns to service. OCC system is not as effective as OMCC system since the reactor must be off-line, which reduces cleaning frequency. Therefore, the efficiency of the UV reactor is always low. Also called "flush-and-rinse" systems.

OMC System

OMC system wipes the sleeve surface with an automatic mechanical wiper (e.g., O-ring), consisting of stainless steel brush rings or Teflon rings, which is driven by an electric motor or a pneumatic piston. Water drainage is not required and the reactor can remain online while the lamp sleeve is being cleaned. However, cleaning efficiency is still less than that of OMCC system.

OMCC System

Similar to OMC system, OMCC system wipes the sleeve surface with an automatic mechanical wiper driven by an electric motor or a pneumatic piston; but it is composed of wiper collars that are filled with chemical cleaning solution and moves along the lamp sleeve. While the cleaning dissolves the foulants, the wiper physically removes them from the sleeve surface. No reactor drainage is required and the UV reactor can remain online while cleaning the lamp sleeve.

Advanced OMCC System

bubble clean™

ECOSET's Bubble Clean System satisfies the disadvantages of conventional OMCC.

In addition to the conventional mechanical and chemical elements of the OMCC, Bubble Clean generates microbubbles, which flow at a high speed along the spiral grooves inside the wiper collar surrounding the quartz sleeves. After the cleaning cycle ends, the cleaning solution returns to a solution tank located above ground. The aboveground solution tank enables the operators to easily drain and refill the solution without shutting down and lifting the UV modules (or draining from the reactor). This advanced OMCC system has an automated monitoring and shut-off system to detect

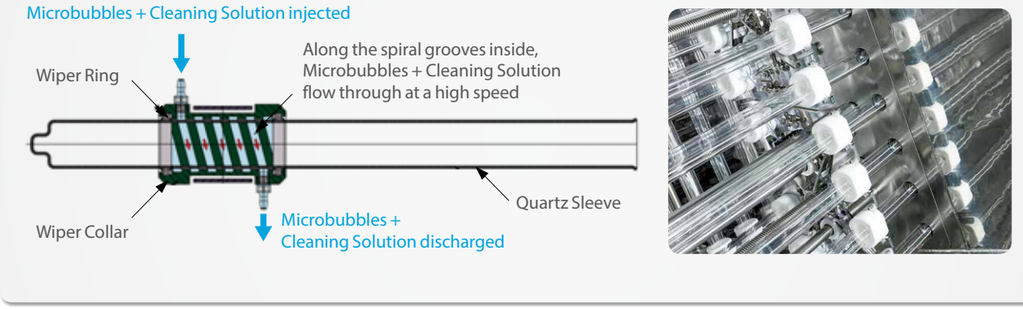
any leaks or damages. Bubble Clean not only maximizes the cleaning efficiency but also provides easy maintenance.

Conventional OMCC System	Bubble Clean System
Continuous contamination by use of injected chemical cleaning solution in wiper collars.	Cleaning solution can be easily checked and replaced/refilled.
Only lower section of quartz sleeve is cleaned if collars-filled cleaning solution runs low	Cleaning solution flows through spiral grooves even if cleaning solution runs low.
The entire cleaning solution must be drained and refilled even if only one quartz sleeve needs to be replaced.	Cleaning solution does not need to be drained and refilled when quartz sleeve is being replaced.
The cleaning solution leaks into UV reactor if wiper ring is damaged	A leak detection and an automatic shut-off system monitor any damage of wiper seals
The entire module needs to be lifted to refill cleaning solution. (It can take several days to replace cleaning solution at a large-scale plant.)	Only the aboveground cleaning solution tank needs to be drained and refilled. (Maintenance time is not dependent on the number of UV modules.)

Acid + Microbubbles + High-Speed Rotation

bubble clean™

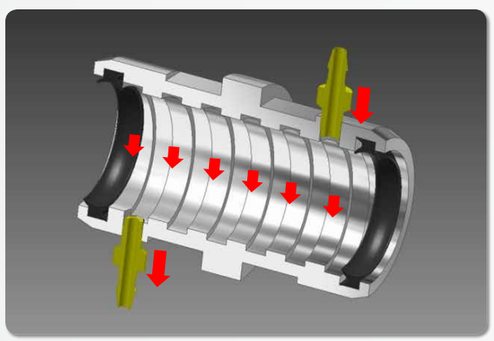
Bubble Clean System improves the performance of UV reactors and reduces the labor costs. This excellent cleaning system consisting of mechanical, chemical, microbubble, and high-speed rotation elements maintains the maximum level of quartz sleeve transmittance.

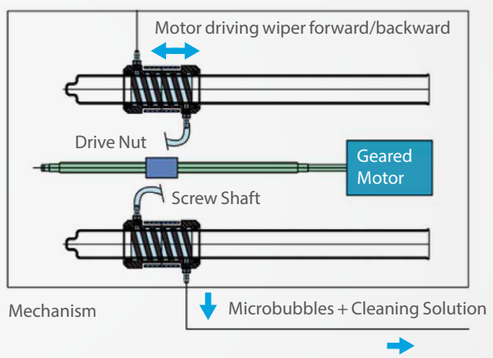


1 WIPER COLLAR OF BUBBLE CLEAN SYSTEM

Principle — Along the spiral grooves inside the wiper collar surrounding the quartz sleeves, chemical cleaning solution with microbubbles flows at a high speed

Maximization of Cleaning Efficiency — Foulants dissolved by chemical cleaning liquid + Cleaning effect of microbubbles + Effect of high-speed cleaning liquid rotation





Online Mechanical-Chemical Cleaning (OMCC) + Microbubbles + High-Speed Rotation

2 ADVANTAGES OF BUBBLE CLEAN SYSTEM

Bubble Clean, the advanced OMCC system with microbubbles, guarantees high quartz sleeve transmittance, which maximizes the performance of UV reactors.

Auto-cleaning at a prescribed frequency without interrupting UV disinfection eliminates maintenance inconvenience and lowers maintenance costs.

3 FEATURES OF BUBBLE CLEAN SYSTEM

01 One aboveground cleaning solution tank supplying many UV modules.

02 No drainage or refill of cleaning solution required when replacing quartz sleeve and UV lamps.

03 Easy to replenish or replace chemical cleaning solution.

04 No decrease in cleaning efficiency due to loss of solution.

05 Automatic notification system to replace cleaning solution.

06 The recovery of entire cleaning solution in the wiper collars when cleaning system stops.

07 Easy to check the contamination level of cleaning solution.

08 No decrease in cleaning efficiency due to contamination.

09 No concern of solution leakage contaminating water to be treated.

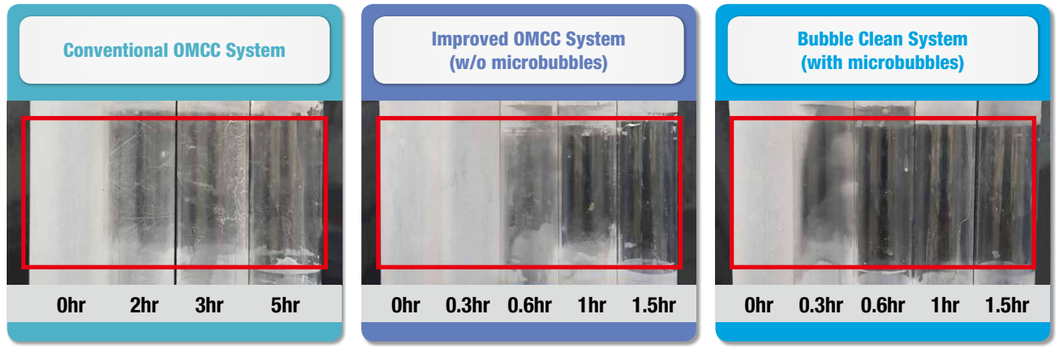
10 Cleaning solution leakage alarm system with automatic leak detection system.

Bubble Clean System

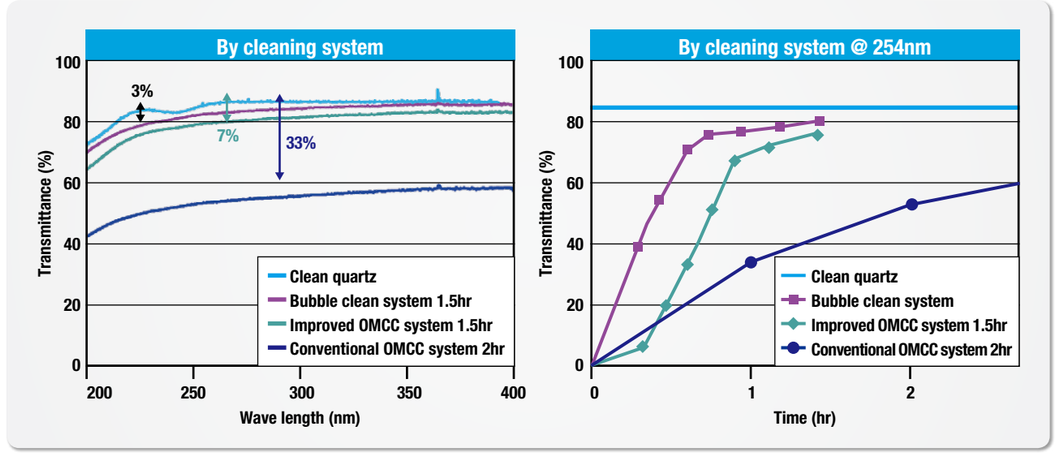
Reference:
Microbubbles collapsing in water release ultrasonic waves and high pressure.

4 COMPARATIVE EXPERIMENT

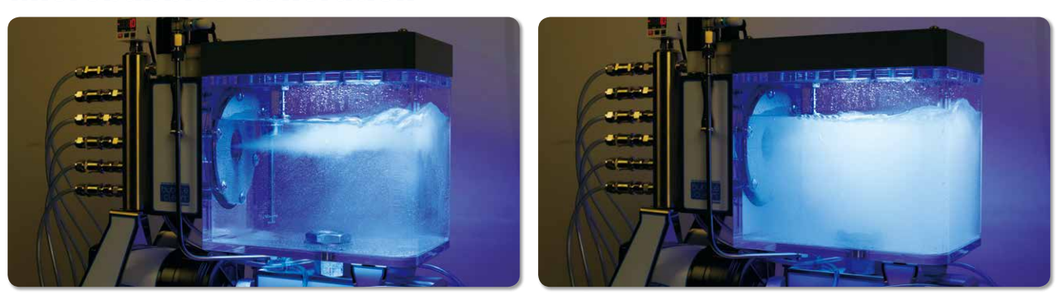
Compared to conventional on-line mechanical-chemical cleaning (OMCC) system, the advanced OMCC system injecting chemical cleaning solution at a high speed through spiral grooves inside the wiper collars surrounding the quartz sleeves showed a better cleaning efficiency in a short period of time. In addition to this high-speed rotation method, the addition of microbubbles has shown even higher cleaning efficiency.



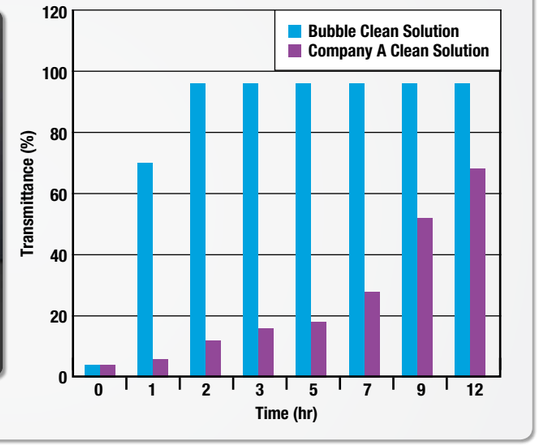
Comparison Graphs of Cleaning Systems



Microbubbles Generation



Comparison with the Competitor's Cleaning Solution



Performance Verification through Testing with Different Types of Quartz Sleeves Fouling

5 FEATURES OF BUBBLE CLEAN SOLUTION

Bubble Clean Solution complies with the National Sanitation Foundation/American National Standards Institute 60 (NSF/ANSI Standard 60: Drinking Water Treatment Chemicals – Health Effects)*.

*Bubble Clean Solution is made from ingredients for food additives.

- Bubble Clean Solution must be used for Bubble Clean System.
- Bubble Clean Solution can withstand low temperatures as low as -4°F (-20°C)
- The contamination level of cleaning solution can be checked with naked eye.